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GREENHOUSE GAS EMISSION FROM ELECTRIC VEHICLE'S AND LI-ION BATTERY – A REVIEW

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ABSTRACT

The Internal combustion engines being used are very popular for production of power in the vehicles. The popularity of internal combustion engine is because of highly energy efficiency, good stability and flexibility to various operations. The internal combustion engine has wide application in agriculture and production of electricity. As the engines are highly popular, they also produce a lot of pollution while working. It is known that, the transport industry has a key role in the country's economy. The transportation sector runs on fossil fuels, which accounts to about 90%. Depleting fossil fuels is a problem, and our future generation will not have any fossil fuels. It is observed that the greenhouse gas emission has grown significantly, because of the use of the fossil fuel-based oils. It was observed that the United States of America emitted 14% of the global greenhouse gases. With concerns about climate and its changes, have made the car manufacturers aware of the need for green vehicles. Green vehicles mean Hybrid electric vehicle and electric vehicles. Many countries have started developing policies in which, they are promoting the hybrid electric vehicles and electric vehicles. But, with the rise in the electric and hybrid electric vehicles, the impact on the environment has to be evaluated. As the hybrid electric vehicles are majorly dependent on the power grid, power grid is majorly fossil fuel based. The effect on GHG emission has to be reviewed.

KEYWORDS: Electric vehicle, Hybrid Electric Vehicle, Li-ion Battery, Emission & CO_2

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A REVIEW

INTRODUCTION

The Internal combustion engines being used are very popular for production of power in the vehicles. The popularity of internal combustion engine is because of highly energy efficiency, good stability and flexibility to various operations. The internal combustion engine has wide application in agriculture and production of electricity. As the engines are highly popular, they also produce a lot of pollution while working. It is known that, the transport industry has a key role in the country's economy. The transportation sector runs on fossil fuels, which accounts to about 90%. As industrialization is increasing day by day, and there is a growing population it is a well-known fact that we will face shortage of the conventional fuels. Depleting fossil fuels is a problem and our future generation will not have any fossil fuels. It is observed that the greenhouse gas emission has grown significantly because of the use of the fossil fuel-based oils. When compared the greenhouse gases in year 1970 to 2014, the gases had increased by 90%. It was observed that the United States of America emitted 14% of the global greenhouse gases. The transportation sector of California produces around 37% of GHG reported in 20151. The burning of the fossil fuels produces a lot of pollution and can lead to a lot of health problems. The pollution can cause respiratory problems and asthma. International Energy Agency reported that the energy demand is increasing every year by

2%. It is expected that by 2035, the Global energy demand will be more than 1/3, and India, China and Middle East will be responsible for the 60% increase [2]. The increase in greenhouse gas from the fossil fuels would be 39% by the year 2030 [3].

With concerns about climate and its changes, the car manufacturers have been made aware of the need for green vehicles. Green vehicles mean Hybrid electric vehicle and electric vehicles. The first hybrid electric vehicle was introduced in Japan. In Japanese households, the penetration of HEV was 9.8%, in the year 2015 as reported by Ministry of Internal Affairs and Communication [4]. China also faces a major challenge, because of the rapid sales of the car. The vehicular emission report of China in the year 2015 revealed, main contributor of pollution is the vehicles which emit 90% particulate matter, NO_x, 80% of carbon monoxide.

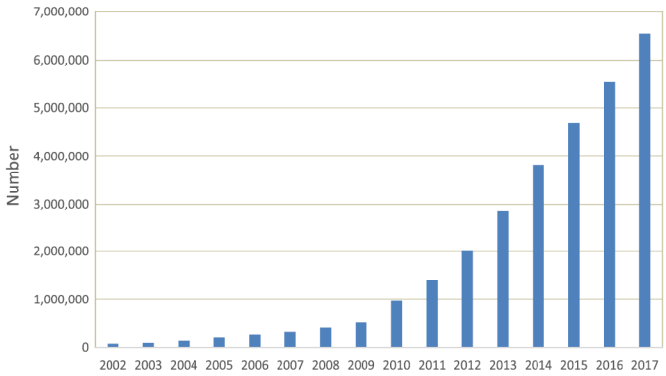

Figure 1: Hybrid Electric Vehicle Trend in Japan [4]

Because of the rising pollution, the Chinese government changed their policies and showed importance in the development of the electric vehicle. The market share of the electric vehicles increased annually. Because of the speedy development of the electric vehicles, public attention was towards the energy and environmental problems. Electric vehicles have more advantages than conventional gasoline vehicles like low noise, no direct emission, rapid acceleration and energy efficiency [34]. It has also been observed that the Li-ion battery generate some amount of pollution. The pollution of the Li-ion battery is greenhouse gases. The emission is generated because of repeated charging and discharging, as well as during manufacturing. But, it was observed that the GHG emission during production was low. The greenhouse emissions are a threat to the environment and human. As the Electric vehicles and the hybrid electric vehicles are growing in number day by day, we should research about the emissions related to the electric and hybrid electric vehicles.

LITERATURE REVIEW

Aaron J. Cheng et al. **[1]** studied about the electric vehicles and how the smart charging can help in reduction of emissions, when the electric vehicles were used on large scale. The paper modelled different algorithm for charging electric vehicles, centralized and decentralized electric vehicles and compared the grid capacity, cost benefits, NO_x reduction benefits and CO_2 reduction. CO_2 emission were found to be same with decentralized approach and centralized approach with 2% NO_x emission, but in only condition when the Vehicle and grid communication frequency were less than 60 min. No_x emission difference were associated with the increase in load, which was caused by the decentralized smart charging frequent communication in high power plant start-up. Frequent grid communication should be constant with increase in the grid capacity and cost. HüseyinTuranArat**[5]**researched experimentally and by simulation about the hybrid

electric vehicles, in which the internal combustion engine was powered by hydrogen (H_2). Hydrogen is enriched through the intake manifold. Hydrogen used in the experiment was an additional fuel as alternate fuel. For experiment, Ford spark Ignition 1.8L was used. 10% H_2 enrichment was tested and the emission and performance were calculated. ICE's properties were compared with the AVL Boost and cruise tool. The experiment results and the simulation results were same and consistent. AVL cruise were used for H_2 enriched ICE and its hybridization. It was observed that the Hybrid mode ICE had better performance and the enrichment of H_2 made it environment friendly. There was an improvement of 2.37% in the power of the ICE and 3.56% improvement in torque with the enrichment of H_2. The enrichment of H_2 helped in reduction of fuel consumption by 12.6% and the emission was reduced by 14-33% in the hybrid mode. AF-HEV had promising output in reducing emission and fuel consumption, and it also improved the performance. Bradley W. Lane et al. **[6]** studied the potential buyers of two different plug-in electric vehicles firstly; the plug-in hybrid electric vehicle and the battery electric vehicles. The observation showed that the plug-in electric vehicles were preferred by most of the people over the battery electric vehicle. The reason for the preference was add on gasoline backup engine, and customers did not want to rely only on the battery. The study was conducted in the late 2013, where the electric vehicles could travel smaller distance. Range anxiety was a frequently cited problem. Though the BEV could manage the daily travel of most of the drivers, the drivers wanted to keep the option of traveling long distance. Many manufacturing companies of BEV and PHEV are providing incentives, and the policy awareness has increased. The changing infrastructure has also expanded itself, and these policies have helping people in moving towards the alternate fuel vehicles and the market share of these models are increasing. It was also noted that the gasoline price have decreased in 2017 from the year 2011, 2014 and it is perceived that the adoption of household fuels have slacked. PHEV have been preferred by household to reduce transportation cost. The paper suggested for future research in the same field. The penetration of PEV's has been low as technological advancement, high battery price. As the technology develops, mere the PEV's will become cheaper and the penetration will be better. Eoin O'Neill et al.**[7]** researched about why popularity of electric vehicles was lagging in Ireland. Ireland had a market share of 0.7% in 2017 of the new electric vehicles. The low market share was because of the lack of promotion and the rising awareness of the electric vehicles, the incentive regime has also been static. It was also seen that the CO_2 reduction was slowly getting poorer in proportion to the policy costs. The market share of the diesel oriented car jumped from 27% in 2007 to 64% in 2010. There was a drastic rise in the use of used diesel vehicles which were imported from United Kingdom after the Brexit, which further damaged the decarbonizing of the transport vehicles and the public health quality also detreated. The Ireland started imposing heavy tax on vehicles emitting higher CO_2. In the late 2017, the government of Ireland introduced new electric vehicle policies even in the public transport fleet and changed the promotional activities. Philip von Brockdorff et al. **[8]** studied the schemes and the effect of using electric vehicles in Malta. By the year 2020, Malta committed to reach 5000 units of battery electric vehicles on the roads because of the EU obligation. Schemes were announced to popularise the electric vehicles. Customers deregistering their old vehicle and registering for new electric vehicle would get €5000 benefit and new customers would get a benefit of €4000. It is observed that the electricity generated in Malta is from fossil fuels and the burning of the fossil fuels would generate a great amount of CO_2, and it would impact the environment. The study included electric, hybrid, diesel and petrol vehicles. It was clearly seen that the electric vehicles emitted more CO_2 than the hybrid, petrol and diesel vehicles. This can be justified, as the use of Heavy fuel oil for the generation of electricity and less renewable energy was being used. The generation of CO_2 would be less, if renewable energy such as natural gas is used for the generation of electricity. Patrick Jochem et al. **[9]** discussed about the different assessment methods marginal electricity mix, average annual electricity mix, balancing zero emissions and average time-dependent electricity mix and to analyze the CO_2 emission in 2030 in Germany.

Optimised controlled charging and uncontrolled charging strategy was discussed. For the year 2030, the CO_2 emission had a substantial Discrepancy, ranging from zero emission to 110 g/km. Electric vehicles are known because of their low CO_2 emission, but some results show that the CO_2 emission are not in favour to the electric vehicles when compared to conventional vehicles. Controlled charging has helped in reducing the CO_2 emission from the power grid. The paper suggested using controlled charging, as it helps in reducing the CO_2 emission from the electric vehicles. The CO_2 emission will be similar, if the power generation is from thermal power plants as conventional vehicles have a reduced emission of about 80g CO_2/km by 2030.

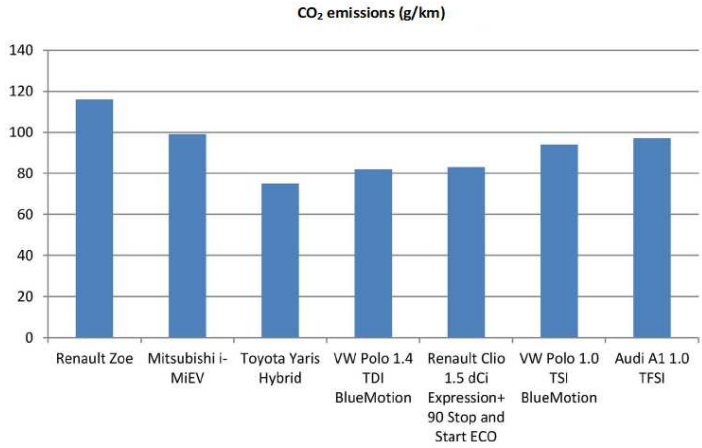

Figure 2: Emission by Vehicle (g/Km) [8]

Measures should be developed to reduce CO_2 by making policies and controlled charging should be promoted to have CO_2 free driving of the electric vehicles by 2030. Juan C. González Palencia et al. **[10]** discussed about the road freight transportation. It was observed that the freight vehicles were mainly using diesel or gasoline internal combustion engine, which are a problem for decarbonization. Vehicle stock turnover model was used for the estimation of electric vehicles and its potential in reducing CO_2. The study was a case study which was focused on Japan. Tank to wheel CO_2 emission in the base scenario was reduced by 51.9% in the year 2012 and 2050 driven by hybrid electric vehicle, vehicle stock reduction and vehicle fuel consumption enhancement. The tank to wheel for CO_2 will reduce to 55.8% if diffusion of fuel cell electric vehicle and battery electric vehicles. Well to wheel CO_2 emission could be reduced upto 43.9% and 27.6%. Even if such hostile measures are taken for electric-driven vehicle, still consumption of fossil fuel would be around 52% in 2050. Yuhan Huang et al. **[11]** compared the hybrid electric vehicles to the internal combustion engine vehicles. It was comprehended that the electric vehicle is less polluting and have high efficiency than the conventional cars. But there have been a number of findings which show that the emissions from the electric vehicles were much higher emissions in the real driving situations than the laboratory approved limits. The advantages of Hybrid Electric Vehicles in the real drive conditions when compared to conventional cars have not been explored. Total of four cars were tested, hybrid and conventional vehicles which were of the same model. The tests were performed simultaneously using portable emission measurement systems. As the tests were performed simultaneously, the various effects such as vehicle configuration, road conditions, driving behaviour and ambient environment on the performance were eliminated. The real driving results in case of fuel consumption for both hybrid and conventional vehicle were higher, 44-100% and 30-82% than the lab results respectively. Compared to internal combustion engine, the hybrid could manage 23-49% better fuel efficiency. The hybrid electric vehicle had no effect on HC emission and CO emissions were uniformly more than conventional cars. Though the pollutants were lower than the prescribed limits for the test vehicles, the rise in emission was because of the frequent stop

and restart of the hybrid engine, more over the exhaust temperature were low, which reduced the effectiveness of the oxidation catalyst. The paper concluded that the hybrid engine could not bring much benefit to the urban air quality. Han Hao et al. **[12]**studied about the effect of the battery electric vehicles on reducing the green house effect in China. The lifecycle cost and green house emission of the hybrid electric vehicle, conventional vehicle and battery electric vehicle were examined. Even their cost effectiveness was compared in contribution to reduce greenhouse gas emission. The results from the paper showed that the battery electric vehicle reduces the greenhouse gas compared to conventional cars, but the cost effectiveness cannot be compared to hybrid electric vehicles. However, till now the cost effectiveness of hybrid electric cars are more than battery electric vehicles. With better power generation efficiency, grid mix optimization, battery cost reduction and improvement in cost effectiveness of battery vehicle, it is anticipated that the battery electric vehicles will have more popularity than the hybrid electric vehicles. Still, the penetration of electric vehicle is uncertain because it depends on the gasoline price. The high cost-effectiveness in fleet such as taxis should be done by developing the battery electric vehicles. Development in technology in terms of both vehicle electrification and power generation are important to improve the cost effectiveness of BEV. M. Taljegard et al. **[13]** investigated in the Scandinavian and German road transport sectors, will be influenced in investing in the latest electricity generation techniques with a stringent CO_2 cap by the year 2050. Cost minimization investment model and electricity dispatch model were applied for Germany and Scandinavian electricity system. Vehicle to grid and optimised charging strategy were assumed to be optimized for passenger electric vehicle. 11 different scenarios were investigated for different electricity development levels and different electric vehicle battery size. Electric buses and trucks using electric road systems were included in two scenarios. Modelling results revealed that the output of the thermal power plant, and the wind power plant had to be increased to meet the demand of the electrified road transport, with a cap on CO_2 emission. It was estimated that in Germany and Scandinavia 7-30%, which depends on the electric vehicle scenario in the year 2030. The model also shows that the CO_2 emission from the electricity generation plants would be around 15 gCO_2/km in the year 2030. By the end of the investigation period i. e. year 2050, CO_2 emissions would be very low, results in investing in wind power energy and thermal energy plants, which would generate energy with the help of CCS lignite co-fired with biomass, covering the additional load. R. Suarez-Bertoa et al. **[14]** investigated the emission impact of the Hybrid electric vehicles and plug-in hybrid electric vehicles of Euro 5 compliant, emission of ammonia, ethanol and acetaldehyde were of unique interest.

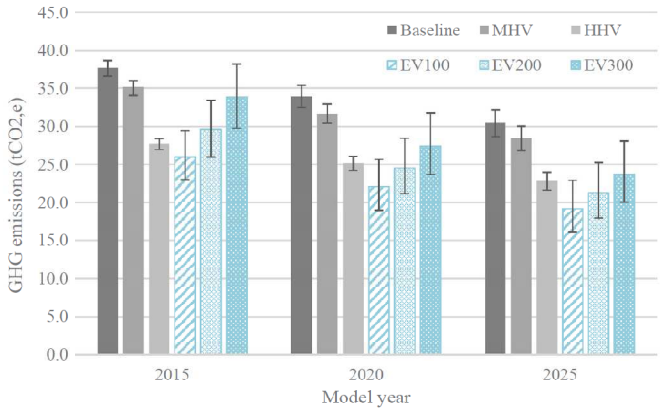

Figure 3: Life-Cycle Greenhouse Gas Emission [12]

It was expected that the light duty hybrid vehicles registration will increase in the coming days, and it will keep on growing. It is very important to anticipate the impact of the emission from the hybrid vehicles. The test was conducted on

world harmonized light-duty test cycle with two different fuels; gasoline containing 5% and 10% vol/vol of ethanol at -7^{o} and 23^{o}C. Plug in hybrid vehicle showed lower emissions than hybrid electric vehicles because of the pure electric strategy employed by PHEV. Ammonia emission at 22^{o}C was 2-8mg/kmat -7^{o}C was 6-15 mg/km, acetaldehyde at 22^{o}C was 0.2mg/km and at -7^{o}C was 0.8-2.7mg/km & ethanol at 22^{o}C was 0.3-0.8 mg/km and at -7^{o}C it was 2.6-7.2 mg/km. the emission were almost the same as of the conventional gasoline vehicles. T. Donateo et al. **[15]**analysed the recharge data of the electric cars in the year 2013 in Rome under a national project. Public Enel Distribuzione was used for recharging the electric vehicles. The time duration was calculated for each recharge and the electricity was calculated, which was absorbed from the grid. Observations revealed that around 7700 vehicles were recharged. The first step in the research was to analyse the recharge time slots by the Italian drivers. The busy tie slots were 10-12am and 1-3pm. For the same time slots, data were acquired from the Italian national grid operator, to check the energy mix that was used to produce that electricity. CO_2, HC, CO, PM, NO_x, and HC + NO_x per 100 km were evaluated for the environmental impact. The results showed that the electric vehicles had the lowest emission compared to the conventional vehicles even in the NEDC driving cycle. The CO emission from the electric vehicle were negligible and electric vehicle are good choice in Italy. Alberto Moro et al. **[16]** discussed about the most widely used methodology that is well to wheel, used for transport sector policy making. The paper concentrated on the 2013 data of European Mix of Carbon intensity. For each European member state, the electricity consumed was calculated. Electricity trade between the countries for the green house gases was calculated, carbon intensity was also calculated, which was affecting the electricity consumed at the national level. Electricity imported from other countries will lower the Carbon intensity of the electricity, but if electricity is imported from a country of higher carbon intensity, it will rise the CI of country importing the electricity. Carbon intensity was calculated in two modes, greenhouse gas combustion emission and combustion and upstream emission. The combustion emission results that were calculated were in limits of the International Energy Agency and the IEA CO_2 emission. The 2013 data of the carbon intensity was 18% lower than the 2009 JEC well to wheel data. This showed that the Europe had a decarbonising trend. Battery electric vehicles show that the greenhouse gases were saved when compared to the internal combustion engine which was gasoline fuelled. It was concluded that, the greenhouse gas saving by the battery electric vehicle was around 50-60% compared to the internal combustion engine. Compared to the internal combustion engine, the battery electric vehicle shower lower GHG emission and are helpful in the future. Bradley W. Lane et al. **[17]** surveyed to find the potential buyers of two different plug-in electric vehicles, first the battery electric vehicle and the plug-in hybrid electric vehicles. Results show that the consumers mostly prefer the PHEV because of the advantage of the backup from the gasoline engine, rather than only relying on the battery for the power. Customers interested in plug-in electric vehicles, prefer it because of its economical benefits such as reduced maintenance cost and need for low gasoline. Customers with environmental concern and technological interest preferred battery electric vehicle. QinyuQiao et al. **[18]** studied the greenhouse gas emissions and life cycle energy consumption of the battery electric vehicle and ICE vehicles. The study was conducted in China. The electric vehicles are equipped with different kind of driving mechanism than the conventional internal combustion engine vehicles. Observations showed that the greenhouse gas emission for the production of battery electric vehicles was 15.0ti 15.2 t CO_2eq and the energy consumed for the production was in the range of 92.4-94.3 GJ. The results were 50% more than the internal combustion engine vehicle production. The internal combustion engine vehicle had greenhouse gas emission of 10 t CO_2eq and energy consumption of 63.5 GJ. The main essential component in a BEV is the traction battery and its production, which mainly increases the GHG and energy consumption results. When observed closely, it was found that the Li-ion battery consumes about 13% of the energy and the greenhouse gas emission of about 20%. Total energy consumption by the materials was 60%, 10% and 7% by steel, aluminium and active materials respectively, and total

energy consumption of 50%, 17% and 11% respectively by steel, aluminium and active materials. It was also seen that the total energy consumption and the greenhouse gas emission could be reduced by 30% if the new vehicles are produced by the recycled material of the old material. WendaiLv et al. **[19]** discussed about the vehicular emission. The major source of air pollution is the vehicular pollution and heavy metal pollution, growing urbanization and economic development also lead to pollution in China. The study was conducted in Yunnan province, having an increasing vehicular population. COPERT IV model was used to estimate the vehicular pollution, bus, heavy duty trucks, cars; light duty vehicles were included in the emission analysis. Vehicular emission analysis of SO_2, NO, CO, NO_x, CO_2, NH_3, NO_2, N_2O, CH_4, VOC, PM_{10}, zinc, PM, cadmium and ambient air non-methane volatile organic compound was done. The pollutants were increasing according to the results. Heavy metals pollutants also increased but SO_2 did not show any changes, even after the strict emission standards. Increase in population of the vehicles lead to the growth of vehicular emission. CO_2 emitted from the vehicle contributes one third of the total CO_2 in Yunnan. CO_2 emission jumped from 25.61% to 52.40% in the year 2003 from the personal cars. Light duty vehicles accounted for about 46.01% of NO_x emission of the total NO_x emission. Main contributor to the rising CO, CO_2, NH_3, CH_4, VOC, zinc and Cadmium was the private cars. L. Athanasopoulou et al. **[20]** studied the well-to-wheel to compare the battery electric vehicle and the internal combustion engine, its contribution to air pollution and the energy required to drive the BEV and its flow from the energy source to the vehicle being driven. Tremendous efforts are being made to reduce CO_2 emission from the automobile and also reducing the greenhouse gases. The use of the in-use consumption valve showed higher CO_2 consumption irrespective of the technology and the type of vehicle. Countries were energy extraction are from renewable energy and nuclear, ICEV are less environment friendly, and battery electric vehicle are more friendly with the environment. Countries where the energy production is based on fossil fuels, the CO_2 emission of the battery electric vehicles are marginally less than the ICEV's. The testing of the vehicles was conducted with NEDC at the pre-production to estimate the greenhouse gas emission and the fuel consumption. The driving cycle research and configuration were made real world, so that actual economy and emission can be estimated. The GHG emission from the BEV are less but the maximum amount of GHG emitted are from the power plants and the generation mixture defines the amount of GHG emitted. As fossil fuels are mainly used for the electricity generation, so, the powerplant directly raises the GHG emission. It was assessed that in the vehicle production mainly energy is used in manufacturing which constitutes about 28% and 38% of the CO_2 is produced, globally. The energy consumption should be managed and research should be followed in the same direction. Rebecca S. Levinson et al. **[21]** analysed the market and simulated to find the possibility of using the public changing infrastructure to motivate the sales of the battery electric vehicles in the US, reduce the greenhouse gas emission and increase the national electrified mileage. Analysis concluded that building DC fast stations would increase the electrified mileage by 8%. Public DC fast charging would be more effective in the large-scale development, than the level 2 chargers in lowering the GHG emission, increasing the electrified mileage and Battery electric vehicle sale. If DC fast infrastructure are pushed and are made popular at national level, there would be sharp rise in the sale of BEV. This could reduce the GHG emission. Slowly, the no of stations has to be increased from 30,000 to 80,000 stations. DC fast stations would show positive and greater output by introducing stations nationally. Eduardo Aparecido Moreira Falcão et al. **[22]** discussed about reducing global warming and reducing emission, and to improve the air quality the only solution is to change to electric vehicles from conventional vehicles which use fossil fuels. A comparative study was carried out between the electric vehicles and the conventional vehicles in urban driving conditions. CO_2 emission from the generation of electricity for the electric vehicles were the performance parameters, and in the case of conventional vehicles, CO_2 emission from the exhaust and the energy consumption was calculated from the heating value and consumption of fuel.

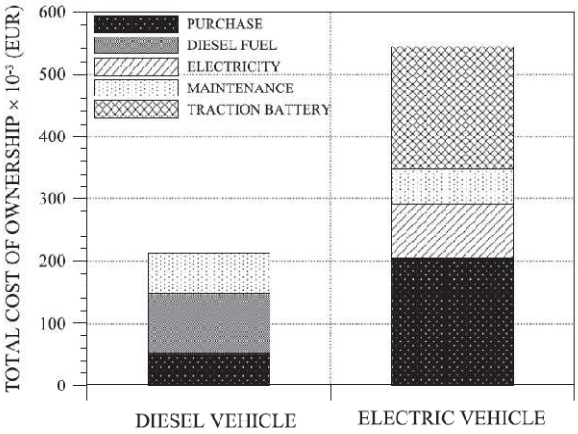

Figure 4: Diesel Vehicle & Electric Vehicle Total Ownership Cost at the End of 15 Years [22]

Different assumptions were established to study the net present value and in terms of playback in terms of economic viability. The leads depicted that CO_2 emission was 4.6 times lower compared to diesel run vehicles. It was also stated that the parts of the EV are spelled and have high rates of exchange, because of which the practicality of the electric cars are compromised. It was also calculated that after 13years of service from the electric vehicle, the payback period would begin. The CO_2emission from the electric vehicles was low than the diesel vehicle even at scenarios of high emission factor. Chiu Chuen Onn et al. **[23]** experimentally calculated the greenhouse gas emission by EV, HEV and ICEV by well-to-wheel life cycle assessment in Malaysia. The Malaysian government has been trying to promote the use of electric vehicles. Also, it is known that benefit can be harvested by generating electricity by low carbon electricity grid only. The observations showed that if the electric vehicles are charged from the national grid, there would be an increase in GHG by 7% for the same distance compared to HEV. When compared to internal combustion engines, the EV produced GHG less by 19%. It is very important to improve the climate, global warming reduction, it is very important to reduce the GHG emission and it can be reduced by transforming towards EV's, and the electricity used for charging the EV's should be from a greener source. Introduction of the electric vehicles will help in improving the national grid by implementing greener grid and helping the policy maker in optimizing and regulating the urban transport by making less emission and making a few power plants, which would be the only source for emission. The observations will help the researches and the policymaker to identify the vehicles which produce more GHG emission, and find an impressive policy for the future transport energy. Riccardo Iacobucci et al. **[24]** studied about the virtual power plant, which could be used for the charging of the shared Autonomous Electric Vehicles. It is expected that the SAEV would become commercially popular within the next decade. The model was tested in different scenarios of transport patterns and weather data for Tokyo, Japan. The results showed that the house holds with a rooftop with solar power shifting from utility power the total cost was 20% lower to VPP with SAEV. But, because of the Japanese grid, the carbon emission would increase and the hybrid vehicles would have better fuel efficiency. But in the case of isolated microgrid, there was a decrease in cost by 16% for SAEV and V2G, the carbon emission was also half, which helps in involving the renewable energy, and the cost is only a fraction of the battery storage. SAAEV have good potential to involve renewable energy, especially when the storage potential is corrected adequately. Axel Ensslen et al. **[25]** studied the time dependent electricity consumption for charging the electric vehicles during driving and charging. Electric vehicles are an effective was to solve the rising CO_2. But the charging of the EV causes CO_2 emission at the power plant. The Electric vehicle travelled a total distance of 38,365km. Individual charging was recorded for 639 vehicles. Different strategies for charging, which could reduce the CO_2 emission were

identified. In the electric power system, CO_2 emission levels change over time. Smart charging is helpful in reducing CO_2 emission from the electric vehicles. The findings revealed that the CO_2 emission for France was only 10% compared to Germany, having diverse carbon intensity. Han Hao et al.**[26]**studied about the energy consumption and greenhouse gas from the production of electric vehicles and the recycling impact, in China. In the global transport sector, the EV has gained a lot of popularity because of its clean vehicle technology. Though the electric vehicle has been promising, but the production of the vehicle produces a lot of emission, more than the conventional ICE engines. It was advised that the recycling could be a way to solve the issue. Compared to the greenhouse gas and energy consumption when the EV are manufactured under two conditions, first there is no recycling circumstance and second the full recycle circumstance by utilizing life cycle assessment framework. It was expected that many EV will reach end of life by 2025 in China, established database. The greenhouse gas from the manufacturing of EV with recycling would be 9.8 t CO_2eq and without recycling would be 14.9 t CO_2eq, depicting a reduction of greenhouse gas by 34% by recycling. Recycling could reduce the greenhouse gas by 10%. Recycling of cathode material of traction battery helped by 13%, aluminium helped by 61% and other helped by 20%. When recycling the conventional cars components, overall reduction contribution was more. In the future, the recycling of the battery would give an immense development. Is was concluded that recycling in very important for lowering GHG, mainly in the case of battery. Ana Carolina Rodrigues Teixeira et al.**[27]**studied the impact of the introducing electric vehicles into the smart grid and the impact on CO_2 emission and energy consumption. Two vehicles were used in the simulation, electric vehicle and engine powered vehicle with AVL Cruise Software, which were operating under New European Driving Cycle. The AVL software was used to calculate the CO_2 emission, energy efficiency and the fuel consumption. The existing CO_2 data of the Brazil electric power plant were compared with the simulated data. Even the impact of introducing taxi fleet which was EV in the SeteLagoas, Brazil into the smart grid was evaluated. Compared to internal combustion engine the CO_2 emission from the electric powered vehicle were 10-26 times lower. EV taxis reduced CO_2 from 9500 to 1400 tons per year. It was noted that even in the case of high CO_2 emission from the power generation plants, there would be a reduction in the annual emissions. Ana Carolina Rodrigues Teixeira et al. **[28]** studied the taxi fleet in Brazil and the internal combustion engines of the fleet were replaced by electric vehicles and the energy consumption and CO_2 were evaluated. The study was conducted with AVL Cruise software. Different scenarios with total or partial fleet were performed in the simulation for a period of 15 years. Favourable and unfavourable conditions were designed for electricity production, which were influencing the CO_2 emission factor were adopted. Simulation revealed that the electricity consumed by the EV were 4 time lower than the energy consumed by internal combustion engine, under standard test condition. Even under unfavourable electricity generation condition the EV showed reduced CO_2 emissions, which were lower than conventional vehicles by 10 factors. Economic analysis showed that the current value of the EV were lower than the convention cars, except the 1st year of buying the vehicle. Shiyu Yan **[29]** researched about the environmental and economic effect by battery electric vehicle, effect of tax bonuses. The government has been giving a lot of incentives for the adaptation of battery electric vehicles; so that environmental benefits could be prevailed. Least square regressions and cost benefit analysis were carried out. Ten pair of vehicles was studied in 28 European countries which included battery electric vehicle and their ICEV counterpart form 2012 year to 2014 year. The electricity produced relies on the technology used, for the emission factor estimation by the power stations. The results showed that the switching cost from ICEV to large BEV were large compared to the switching cost from the counterpart ICEV to small BEV's, under the incentive scheme. BEV sales showed an increase by 3% when the total tax incentives increased by 10%. It was conveyed that even after the heavy incentives the CO_2 emission reduction and other environment factors could not be improved by transport electrification. Weeberb J. Requia et al. **[30]** reviewed about the effect of

electric vehicles on GHG emission, air pollution and health effect on human. The implications of the electric vehicles on the environment were studied. The effect on health and environment by the electric vehicle were evaluated. The study showed that the emission was reducing; greenhouse gas reduced, but in the case of SO_2 and PM that were fluctuating. The findings in the paper were related to geography, electricity generation and manufacturing. Electric vehicle showed substantial reduction in CO_2 emission. Christopher G. Hoehne et al. **[31]**optimized the electric vehicle charging from the grid to minimize the CO_2 emission. The EV has been seen as a new and rising technology which could help in reducing the CO_2 emission. Different time of the have not been researched much to minimize the CO_2 emission. Everyday strategies were explored in the region of US to minimize the emissions from the Plug-in electric vehicles. Standard changing and vehicle to grid charging for plug-in electric vehicle were compared with optimized schedules and pre timed charging to see if CO_2 emission characteristics reduction with marginal energy generation trends, charging characteristics and regional driving. It was observed that optimised charging reduced the emission for standard to 31% and vehicle to grid to 59% compared to pre-timed charging. In some situations, the CO_2 emission increased to 369g CO_2/mile for vehicle to grid by dismissing carbon intense generation period. Plug-in electric vehicle can have a varying charging emission. Current energy efficiency could give wrong assumptions when compared to conventional gasoline vehicle because of temporary emission and different region. To achieve reduced GHG emission, plug-in electric vehicle charging time should search for times where the CO_2 emission would be less. Electric vehicle should be promoted whose energy efficiency is high. Yuhan Liang et al **[32]** optimized the design of the secondary lithium ion battery. They used carbon footprint and proposed the lifecycle assessment. Manufacturing technology and improving materials were proposed to reduce the greenhouse gas emission and sustainable development of the product could be promoted. Carbon footprint was prevailed in stages and reduction schemes were enforced. Lithium ion secondary battery, solar cell & nickel metal hydride battery were compared and evaluated. The observations from the different batteries showed that for 1000 kW functional unit lithium iron phosphate battery gave 12.7 kg CO_2eq, Ni-MH 124 kg CO_2eq and the solar cells was 95.8kg CO_2eq. Li-ion battery showed environment friendliness. Different producing pollution links were found by lifecycle impact assessment. The repeated charging and discharging made more GHG emission from the Li-ion battery, whereas the transport stage, raw material, assembly stage and the production stage produced very less GHG emission. Electrochemical performance of the Li-ion battery should be ameliorated so the charge and discharge loss could be abridged. Anna Boyden et al **[33]** investigated the recycling of the Li-ion battery and the process used for them. The process was compared and environmental impacts were concentrated. Cobalt, copper and nickel were the most recovered material. More than pyrometallurgical processes, hydrometallurgical processes regained more material. Lifecycle assessment compared the pyrometallurgical process & hydrometallurgical the environmental impact results showed that pyrometallurgical processes caused more global warming because of plastic incineration, terrestrial ecotoxicity potential and electricity generation for human toxicity potential. Hydrometallurgical process depicted more impact than pyrometallurgy and landfill within the global warming potential impact category, greatest impact for toxicity was showed by landfill. Transport of waste battery had significant impact. Global warming increases by battery transport from Australia to Europe, 45% by pyrometallurgical processes and 550% human toxicity potential by hydrometallurgical processes. The impact could be reduced by decreasing the distance of collecting and recycling.

CONCLUSIONS

This is a review paper, and it focused on the emissions from the electric vehicles and battery electric vehicles. During the review, it was noticed that the emissions were generated from the battery of the electric vehicles also. The

following conclusions were drawn from different engineers and researchers:

- The hybrid electric vehicle was more preferred than the battery electric vehicle; it was because of the additional IC engine which could help to drive the vehicle to far places without worrying about the charging.
- PHEV were preferred by the household, because it could reduce the transportation cost.
- Compared to ICEV the HEV showed better fuel efficiency of 23-49%
- Hybrid mode ICE with hydrogen enrichment had better performance and environment friendly. The enrichment helped to reduce the emission by 14-33% and fuel consumption by 12.6%.
- CO_2 emissions were found to be similar with centralized and decentralized charging. No_x emission difference was associated with the increase in load which was caused by the decentralized smart charging frequent communication in high power plant start-up.
- Ireland introduced new policies to make electric vehicles popular, in 2017 the share of EV were only 0.7%.
- Charging the electric vehicle produced GHG emission. If renewable energy such as natural gas were used for electricity generation the emissions could be lowered.
- Discussion on optimized controlled and uncontrolled charging was discussed and was found that the controlled charging of the electric vehicle would help in reducing the CO_2 emission.
- The road freight transport use diesel or gasoline engine which is a problem for decarbonization. Tank to wheel CO_2 emission was reduced to 51.9% if hybrid electric vehicles were used & if FCEV and BEV are used then the tank to wheel CO_2 emission would reduce to 55.8%.
- Output of the thermal and wind power plants had to be increased to meet the demand of the electric road transport. CO_2 emission from the electricity generation plants would be around 15 gCO_2/km in the year 2030.
- The GHG emission from the BEV are less, but the maximum amount of GHG emitted are from the power plants and the generation mixture defines the amount of GHG emitted. As fossil fuels are mainly used for the electricity generation, the powerplant directly raises the GHG emission. It was assessed that in the vehicle production mainly energy is used in manufacturing which constitutes about 28% and 38% of the CO_2 is produced globally.
- If DC fast infrastructure are pushed and are made popular at national level, there would be sharp rise in the sale of BEV, which could reduce the GHG emission.
- Smart charging is helpful in reducing CO_2 emission from the electric vehicles. The findings revealed that the CO_2 emission for France was only 10% compared to Germany, having diverse carbon intensity.
- Compared to internal combustion engine, the CO_2 emission from the electric powered vehicle were 10-26 times lower. EV taxis reduced CO_2 from 9500 to 1400 tons per year.
- 1000 kW functional unit lithium iron phosphate battery gave 12.7 kg CO_2eq, Ni-MH 124 kg CO_2eq and the solar cells was 95.8kg CO_2eq. Li-ion battery showed environment friendliness. The repeated charging and discharging made more GHG emission from the Li-ion battery, whereas the transport stage, raw material, assembly stage and the production stage produced very less GHG emission.

- Transport of waste battery had significant impact. Global warming increases by battery transport from Australia to Europe, 45% by pyrometallurgical processes and 550% human toxicity potential by hydrometallurgical processes.

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